Report for 2005IN177B: Characterizing hydrologic response in urbanizing watersheds in Indiana: Determination of changes in runoff coefficients

Publications

- Other Publications:
  - http://www.indiana.edu/~ecohydro/MCRR/

Report Follows

IWRRC Report

Title: Characterizing hydrologic response in urbanizing watersheds in Indiana: Determination of changes in runoff coefficients

Submitted by:

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Problem:

When agricultural, or undeveloped areas, are converted to subdivisions and commercial development, roads are built, vegetation is removed, and an engineered drainage network is established. The water cycle for the catchment, or watershed, is altered in a way that increases the amount of water that runs off and decreases the amount stored in the catchment. When natural vegetative cover is removed during development and replaced by yards that drain into local streams or pipe networks, the reduction in landscape storage for precipitation assures that more runoff will occur throughout the year in response to rainfall events. The swails and gutters help to accelerate the stream response so that the peak flow occurs soon after the end of a storm. In many different watersheds around the country, rainfall-runoff data show the degree to which there are changes in both the magnitude and the timing of runoff caused by development (Konrad, 2003). Research done in surrounding states (Illinois, Michigan, and Wisconsin) indicates that there is a threshold density and distribution of residential development that may be a tipping point for stormwater impacts.

Over the past two years the Indiana Department of Environmental Management has developed a new rule and guidance material for implementing phase two of the Clean Water Act (Rule 13). This new rule is designed to reduce the water quality impairments caused by stormwater inflows to Indiana's streams and rivers. The basic premise is that the diffuse development that occurs in watersheds in urban and urbanizing areas needs to account for the increases in stormwater runoff that is caused by the impervious areas in the watersheds of the state. These new rules are to be implemented by the designated MS4 operator with limited background and in most cases, very limited funding. While it is not uncommon for Indiana's municipal governments to bear the burden of a new state regulation, it is unusual that this rule is being imposed on local governments that have no basis upon which to make informed judgments. The stormwater management plans that the counties and local governments are writing require an understanding of the performance and appropriateness of different best management practices. The critical

information needed is the relation between development patterns and hydrologic response in a sub-watershed.

Research Objectives

The objective of this study is to investigate runoff ratios of urbanizing areas in Monroe County, Indiana and to put in place a long-term monitoring study to monitor a broader suite of hydrological variables and to evaluate and develop. To reflect this, the objectives of the study are formulated in two parts:

Short-term objective:

- To gather runoff and rainfall data, with land cover and land use information, through time in areas that are urbanizing to evaluate how rainfall runoff ratios change with urbanization in a Midwestern area.

Longer term objectives:

- To document all aspects of the urban water balance within urbanizing watersheds, including rainfall, piped water supply, runoff, evapotranspiration, and change in soil moisture.
- To evaluate models of the urban water balance which have potential to inform planning decisions related to regional water demand and low flow water quality, as well as storm water management.

This report focuses on the short-term objectives only and the collection of data to date.

Methodology

During the early part of the project period, while conversations with Monroe County Drainage Board (MCDB) were occurring about the most feasible areas for discharge measurements to occur, rain gauges were installed in a number of different areas in Monroe County (MC) (Figure 1). After practical considerations of the flow measurements and future development in MC were taken into account, it was decided to constrain the data collection efforts to the Ellettsville area of MC (Figure 1d). As this is the area of ongoing effort, this report is primarily concerned with work in this area. Additional information can be provided on the other sites and data upon request.

- Several tipping-bucket rain gauges have been placed in an urbanizing area close to Ellettsville (Figure 1) to measure rainfall intensity and amount (Table 1).
- Two pressure sensors and staff gauges have been installed in nearby streams (Figures 1 and 2) to measure flow rates of the streams, and therefore the corresponding discharge that will enable us to model the runoff rates based upon the rainfall data.
- A summary of the sites and data collected at each site is provided in Table 1 below. More details and panoramic images for each of the sites are provided by

following site links at the MCRR project web site:
http://www.indiana.edu/~ecohydro/MCRR/

Table 1: Raingauge sites that are part of the Ellettsville data set

Site	Details
Elletsville Fire House (EFH)	Ellettsville Fire House (EFH) N Coordinate: 39°13'46.3" W Coordinate: 86°37'7.9" Elevation (m): 210.9 LULC type (not official): Urban – Medium Density Grass lot Raingauge make: Sierra-Misco Environment LTD. Model: 2501 Serial #: 1398C Radius (mm): 107.95 Manufacturer tip rate (mm/tip): 0.1 Calibrated tip rate (mm/tip): 0.2291
Langvardt House (LH)	N Coordinate:39°13'33.6" W Coordinate:86°34'58.8" Elevation (m): 253.0 LULC type (not official): Suburban – Low Density Raingauge make: Texas Electronics, Inc. Model: TR-525M Serial #: 20180 Radius (mm): 122.5 Manufacturer tip rate (mm/tip): 0.1 Calibrated tip rate (mm/tip): 0.1141
Elletsville Utilities (EU)	N Coordinate: 39°14'19.3" W Coordinate: 86°37'22.8" Elevation (m): 205.7 LULC type (not official): Utilities – Grass lot Raingauge make: Climatronics Corp. Model: 100508 Serial #: 960 Radius (mm): 76.2 Manufacturer tip rate (mm/tip): 0.1 Calibrated tip rate (mm/tip): 0.2940
Wittman House (WH)	N Coordinate: 39°10'00.5'' W Coordinate: 86°31'31.5'' Elevation (m): 265.5 LULC type (not official): Suburban – Low

	Density Raingauge make: Texas Electronics, Inc. Model: TR-525M Serial #: 10572-492 Radius (mm): 122.5 Manufacturer tip rate (mm/tip): 0.1 Calibrated tip rate (mm/tip): 0.0966
Wal-mart (WM)	N Coordinate: 39°08'32.9" W Coordinate: 86°34'25.9" Elevation (m): 248 LULC type (not official): Urban – Medium Density Grass lot Raingauge make: Texas Electronics, Inc. Model: TR-525M Serial #: 10571-492 Radius (mm): 122.5 Manufacturer tip rate (mm/tip): 0.1 Calibrated tip rate (mm/tip): 0.1345
Stout's Creek (SC)	N Coordinate: 39°11'12.4" W Coordinate: 86°34'14.8" Elevation (m): 238.7 LULC type (not official): Agricultural - Pasture Raingauge make: Qualimetrics, Inc. Model: 6011-B Serial #: 1265 Radius (mm): 104.03 Manufacturer tip rate (mm/tip): 0.1 Calibrated tip rate (mm/tip): 0.1119

Some characteristics of the study area: slopes and elevation (Figure 3); hypsometric curve (Figure 4); and probable land-cover in 1997 (Figure 5).

Principal Findings

A web site for the project has been created where data are reported in real-time: http://www.indiana.edu/~ecohydro/MCRR/. Archives of all previous data are included here on the web site too. These are not reproduced here.

Rating curves for the stream gauging sites are presented at: http://www.indiana.edu/~ecohydro/MCRR/index.php/archives/category/data/rating-curves/

Data collection is ongoing. Analyses are now being initiated of rainfall-runoff ratios and relations to levels of urbanization/nature of land-cover change.

Significance

Results will be used to document effects of urbanization on urban runoff, with implications for water supply and quality. Best Management Practices for minimizing and mitigating negative effects will evaluated and demonstrated to developers.

Publications

Web site: http://www.indiana.edu/~ecohydro/MCRR/

Students

Many students were involved in this project and were an integral part of its success.

Graduate Students:

- Valerie Anderson, Department of Geography, Indiana University
- Bin Deng, Department of Geography, Indiana University

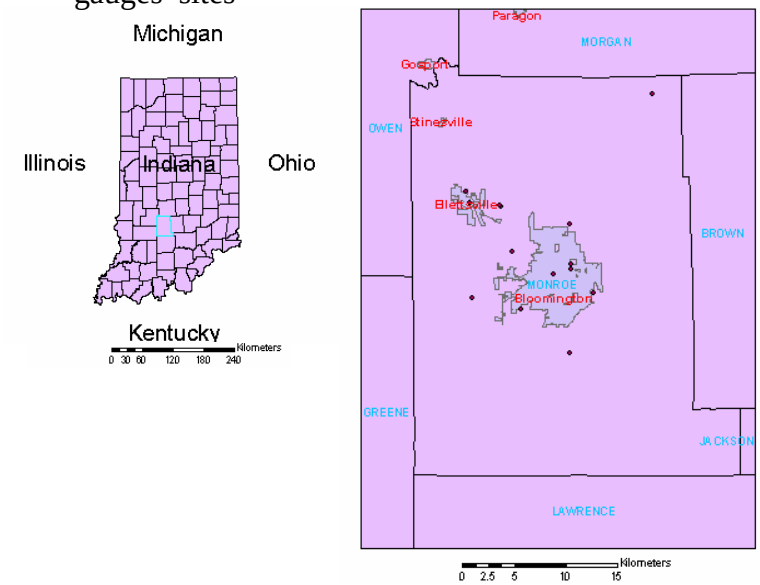
Undergraduate Students:

- Ryan Aylward, Department of Geography, Indiana University
- Jenny Davis, Environmental Sciences Program, Indiana University
- Holly Rauwolf, Department of Geography, Indiana University
- Jake Irvin, Department of Geography, Indiana University
- Nate Langwald, Department of Geography, Indiana University
- Adam Souder, Department of Geography, Indiana University
- Justin Wood, Department of Geography, Indiana University

These students have worked on the project on an hourly-basis and/or also completed course projects (notably in the Field Methods and Instrumentation Course: G350 and GIS courses) and independent studies. In addition, 5 students in G405/505 Hydroloclimatology are using the data from the MCRR project and the sites as a basis for conducting their own independent class research projects.

Invaluable support has also been provided by Steve Scott, Field & Instrument Scientist, Department of Geography, Indiana University and Angela Martin, Field & Instrument Scientist, Department of Geography, Indiana University

Figure 1. Location of Monroe County within Indiana, the associated cities and towns (red) in relation to the raingauge sites. In (b) the adjacent counties are listed in cyan (c) . The raingauge sites and water bodies. (d) Detail of the Ellettsville rain gauges sites



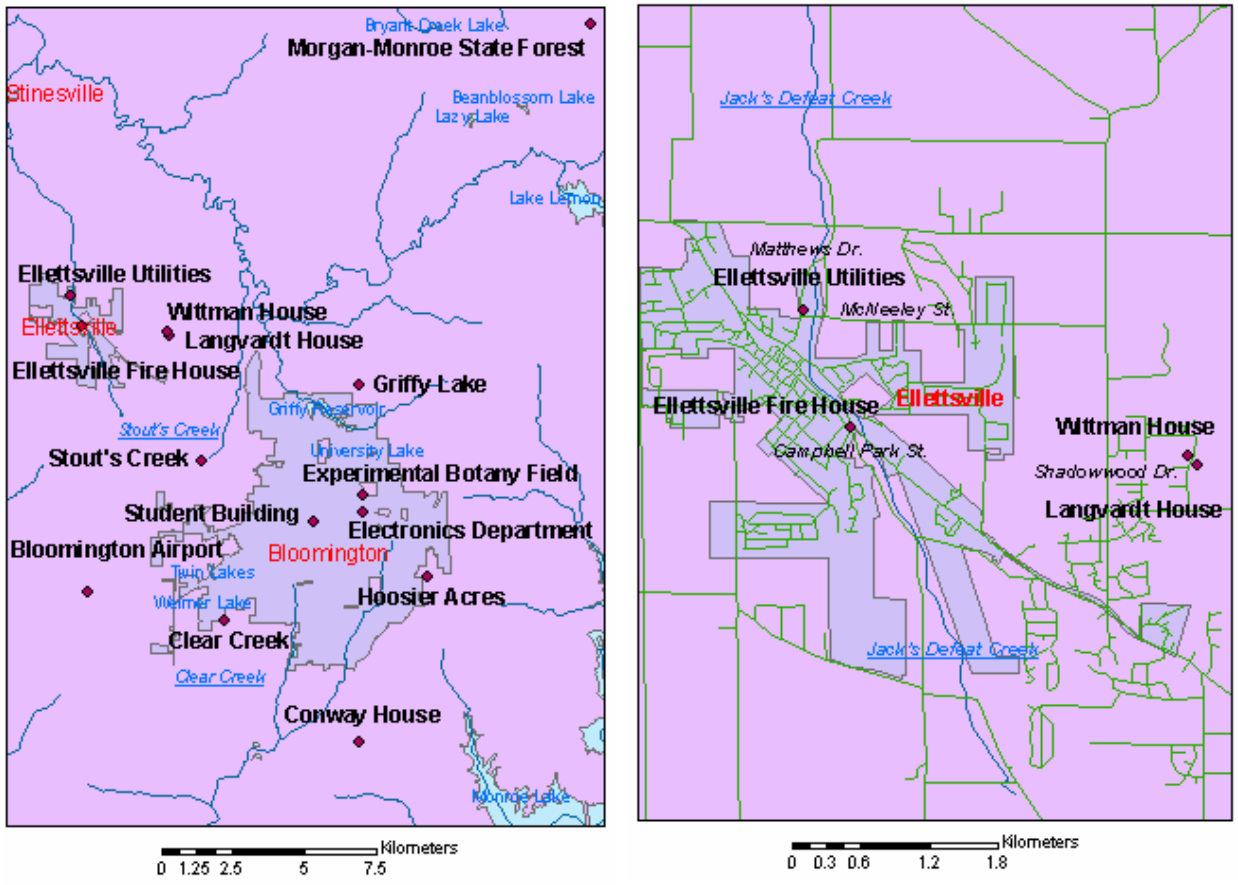


Figure 2: Stream location and gauging sites TBC- Turtle Back Creek and JDC: Jack Defeat's Creek on the

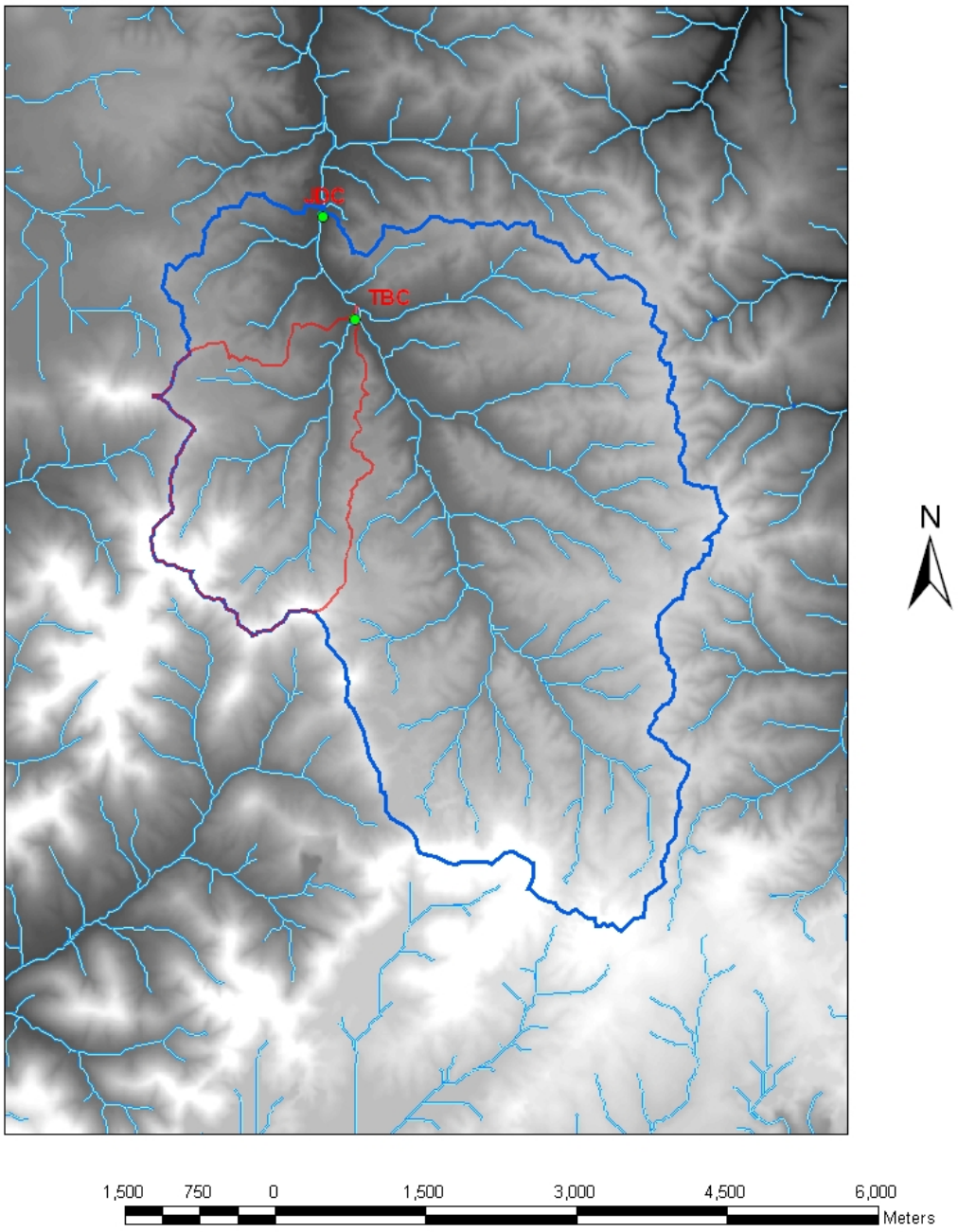


Figure 3: Slope and elevation within the catchment areas

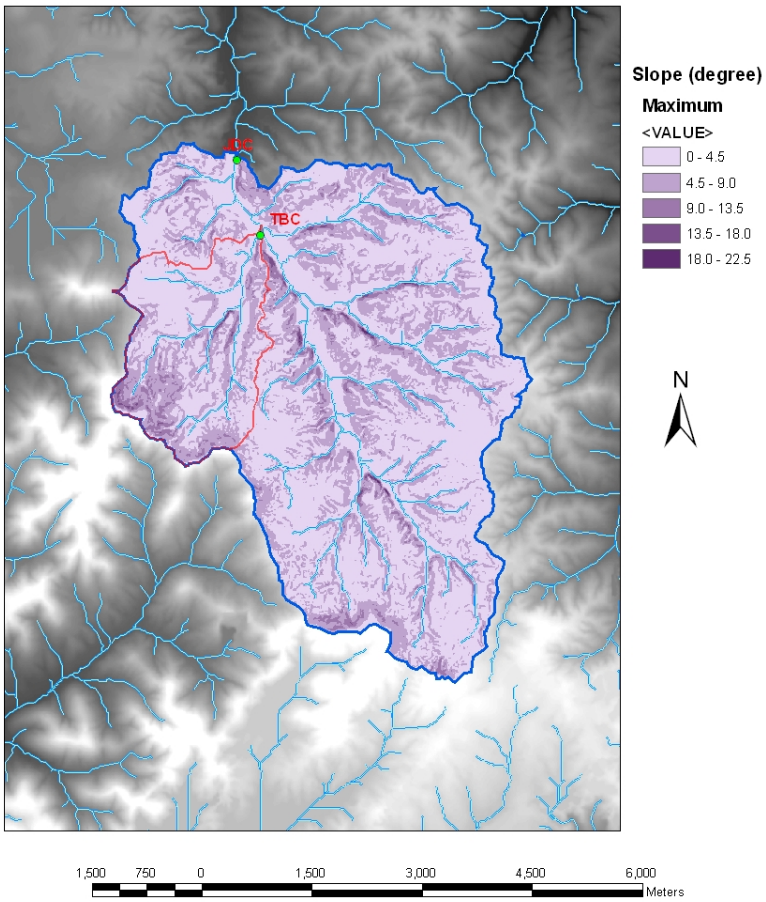


Figure 4: Hypsometric curves for JDC and TBC watersheds

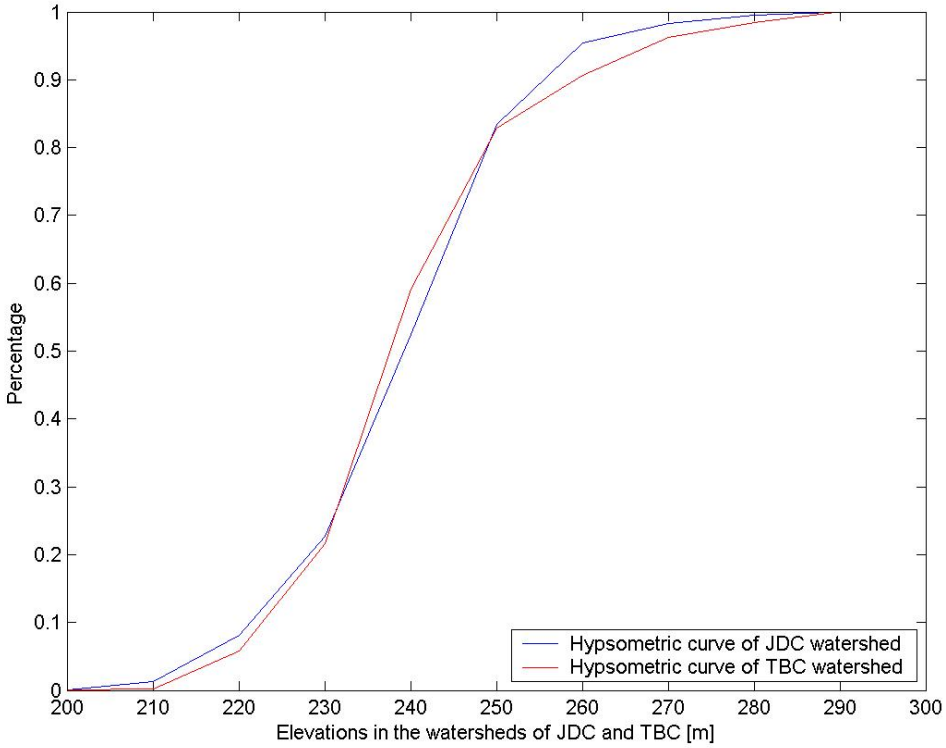


Figure 5: Probable land use land cover in the area based on the 1997 Indiana Land Use Land Cover (LULC) map. 2: Tree; 3-5: Grass/Agriculture/Soil 6-7: Built 8: water